AMENDMENT

To: Examiner of the Patent Office

1. Identification of the International Application
PCT/JP2004/014790

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4. Item to be Amended: Claims and Description

5. Content of Amendment

(1) In the description, lines 15 to 19 on page 4, "Si is in a specific range considerably narrower than usual, by making the contents of Ti, Nb, Mo, and B specific ranges and making the total amount of addition within a suitable range" is amended to "Si is limited to a specific range, further the contents of Ti, Nb, Mo, and B are made specific ranges and the total amount of addition is made within a suitable range".

(2) In the description, line 15 on page 5, "0.64 to less than 0.92" is amended to "0.64 to less than 0.90".

(3) In the description, line 16 on page 5, "TSxEl" is amended to "$TSxEl^{1/2}$".

(4) In the description, lines 30 on page 5, "0.68 to less than 0.92" is amended to "0.72 to less than 0.90".

(5) In the description, lines 17 to 18 on page 13, "0.68 to less than 0.92" is amended to "0.72 to less than 0.90".

(6) In the description, line 19 on page 13, "less than 0.68" is amended to "less than 0.72".

(7) In the description, line 23 on page 13, "0.92 or more" is amended to "0.90 or more".

(8) In the description, line 27 on page 13, "less than 0.92" is amended to "less than 0.90".

(9) In the description, lines 31 to 32 on page 13, "0.72 to 0.90, still more preferably 0.76 to 0.88" is amended to "0.76 to 0.88".

(10) In the description, line 2 on page 19, "TSxEl" is amended to "$TSxEL^{1/2}$".

(11) In the description, line 2 on page 19, "TSxEl≥" is amended to "$TSxEL^{1/2}\geq$".

(12) In the claims, "0.64 to less than 0.92" of claim 1 (page 49) is amended to "0.64 to less than 0.90".

(13) In the claims, "TSxEl" of claim 1 (page 49) is amended to "$TSxEL^{1/2}$".

(14) In the claims, "0.68 to less than 0.92" of claim 3 (page 49) is amended to "0.72 to less than 0.90".

6. Inventory of Attached Documents

(1) New page of page 4, 1 sheet

(2) New page of page 5, 1 sheet

(3) New page of page 13, 1 sheet

(4) New page of page 19, 1 sheet

(5) New page of page 49 (claims 1 to 3), 1 sheet

performance due to the effect on secondary materials, that is, it was difficult to satisfy all of the needs.

To deal with this, upper and lower limits have been set for the amounts of addition of these elements, but even this cannot be said to be sufficient.

In particular, up to now there has not been any range of limitation of components satisfying all at once the high yield ratio and ductility and weldability required for recent automobile frame parts. This has become one of the challenges to be solved by R&D personnel.

Therefore, the inventors engaged in various studies to provide the above steel sheet and as a result took note of the relationship between the range of Si and specific elements and discovered that when Si is limited to a specific range, further the contents of Ti, Nb, Mo, and B are made specific ranges and the total amount of addition is made within a suitable range by a relation using specific coefficients to balance the different elements with each other, a high yield ratio and ductility can both be achieved and weldability can also be provided and further discovered that by producing the sheet under suitable hot-rolling and annealing conditions, these performances can be improved more.

Regarding the yield ratio, the fact that a higher ratio is advantageous from the viewpoint of the collision absorption energy was explained above, but if too high, the shape freezability at the time of press formation becomes inferior, so it is important that the yield ratio not be 0.92 or more.

The present invention was completed based on the above discovery and has as its gist the following:

(1) High yield ratio high-strength thin steel sheet superior in weldability and ductility, characterized by: being comprised of steel containing, by mass%,

C: over 0.030 to less than 0.10%,

Si: 0.30 to 0.80%,

Mn: 1.7 to 3.2%,

P: 0.001 to 0.02%,

S: 0.0001 to 0.006%,

Al: 0.060% or less,

N: 0.0001 to 0.0070%,

containing further

Ti: 0.01 to 0.055%,

Nb: 0.012 to 0.055%,

Mo: 0.07 to 0.55%,

B: 0.0005 to 0.0040%, and

simultaneously statisfying

$1.1 \leq 14 \times Ti(\%) + 20 \times Nb(\%) + 3 \times Mo(\%) + 300 \times B(\%) \leq 3.7$,

the balance comprised of iron and unavoidable impurities, and having a yield ratio of 0.64 to less than 0.90, a $TS \times El^{1/2}$ of 3320 or more, an $YR \times TS \times El^{1/2}$ of 2320 or more, and a maximum tensile strength (TS) of 780 MPa or more.

(2) High yield ratio high-strength thin steel sheet superior in weldability and ductility as set forth in (1), characterized by further containing, by mass%, one or two of

Cr: 0.01 to 1.5%

Ni: 0.01 to 2.0%,

Cu: 0.001 to 2.0%,

Co: 0.01 to 1%,

W: 0.01 to 0.3%.

(3) High yield ratio high-strength hot-rolled steel sheet superior in weldability and ductility as set forth in (1) or (2), characterized in that said yield ratio is 0.72 to less than 0.90 and in that an X-ray intensity ratio of a {110} plane parallel to the sheet surface at 1/8 the thickness of the steel sheet is 1.0 or more.

(4) High yield ratio high-strength cold-rolled steel sheet superior in weldability and ductility as set forth in (1) or (2), characterized in that said yield ratio is 0.64 to less than 0.90 and in that an X-ray intensity ratio of a {110} plane parallel to the sheet

ductility and weldability can be secured with a good balance is not clear, but it is believed that the strength of the ferrite and the hardness of the bainite are suitably balanced and the contradictory characteristics of a high yield ratio and good ductility can be both achieved.

Further, for the weld zone as well, it is believed that the distribution of the hardness of the nuggets and HAZ (heat affected zone) becomes smooth. The range of the above relationship was made 1.1 to 3.7. If less than 1.1, a high yield ratio is difficult to obtain and the weld strength also falls.

Further, if over 3.7, the ductility deteriorates, so 3.7 is made the upper limit. A more preferable range is

$$1.5 \leq 14 \times Ti(\%) + 20 \times Nb(\%) + 3 \times Mo(\%) + 300 \times B(\%) \leq 2.8.$$

The yield ratio of the steel sheet obtained in the present invention is, with a hot-rolled steel sheet, 0.72 to less than 0.90 and, further, with a cold-rolled steel sheet, 0.64 to less than 0.90. If less than 0.72 in the case of hot-rolled steel sheet and if less than 0.64 in the case of cold-rolled steel sheet, a sufficient collision safety cannot be secured in some cases.

On the other hand, if 0.90 or more in the case of hot-rolled steel sheet and if 0.90 or more in the case of cold-rolled steel sheet, the shape freezability at the time of press formation deteriorates, so the upper limit is made less than 0.90 in the case of hot-rolled steel sheet and less than 0.90 in the case of cold-rolled steel sheet.

In the case of hot-rolled steel sheet, the ratio is more preferably 0.76 to 0.88. Further, in the case of cold-rolled steel sheet, the ratio is more preferably 0.68 to 0.88, still more preferably 0.74 to 0.86. Note that the yield ratio is evaluated by a JIS No. 5 tensile test piece having a direction perpendicular to the rolling direction as a tensile direction.

area rate of the different phases.

$TSxEl^{1/2}$ is preferably $TSxEl^{1/2} \geq 3320$ for obtaining a superior ductility assuming a high-strength steel sheet having a tensile strength of 780 MPa or more. If less than 3320, the ductility cannot be secured in many cases and the balance of strength and ductility is lost.

Further, $YRxTSxEl^{1/2}$ is preferably $YRxTSxEl^{1/2} \geq 2320$ or more in order to obtain a high yield ratio and superior ductility assuming a high-strength steel sheet having a tensile strength of 780 MPa or more. If less than 2320, the yield ratio or ductility cannot be secured in many cases and the balance is poor.

Next, the inventions of the above (9), (10), and (11), that is, the methods of production of the high yield ratio high-strength hot-rolled steel sheet superior in weldability and ductility, high yield ratio high-strength hot-dip galvanized hot-rolled steel sheet, and high yield ratio high-strength hot-dip galvannealed hot-rolled steel sheet will be explained.

The steel components may be adjusted by the usual blast furnace-converter method or an electric furnace etc.

The casting method is also not particularly limited. The usual continuous casting method, ingot method, or thin slab casting may be used to produce a cast slab.

The cast slab may be cooled once, reheated, then hot-rolled or may be directly hot-rolled without cooling.

Once the temperature falls below 1160°C, the sheet is heated to 1160°C or more. If the heating temperature is less than 1160°C, due to segregation and other effects, the product deteriorates in bendability and hole-expandability, so 1160°C is made the lower limit. Preferably, the temperature is made 1200°C or more, more preferably 1230°C or more.

The final finishing temperature of the hot-rolling is made the Ar_3 transformation temperature or more. If

CLAIMS

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Mn: 1.7 to 3.2%,

P: 0.001 to 0.02%,

S: 0.0001 to 0.006%,

Al: 0.060% or less,

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containing further

Ti: 0.01 to 0.055%,

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simultaneously statisfying

$1.1 \leq 14 \times Ti(\%) + 20 \times Nb(\%) + 3 \times Mo(\%) + 300 \times B(\%) \leq 3.7$,

the balance comprised of iron and unavoidable impurities, and

having a yield ratio of 0.64 to less than 0.90, a $TS \times El^{1/2}$ of 3320 or more, an $YR \times TS \times El^{1/2}$ of 2320 or more, and a maximum tensile strength (TS) of 780 MPa or more.

2. High yield ratio high-strength thin steel sheet superior in weldability and ductility as set forth in claim 1, characterized by further containing, by mass%, one or two of

Cr: 0.01 to 1.5%

Ni: 0.01 to 2.0%,

Cu: 0.001 to 2.0%,

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3. High yield ratio high-strength hot-rolled steel sheet superior in weldability and ductility as set forth in claim 1 or 2, characterized in that said yield ratio is 0.72 to less than 0.90 and in that an X-ray intensity ratio of a {110} plane parallel to the sheet surface at